APPROPRIATE TECHNOLOGY IN CIVIL ENGINEERING

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Michael G. McGarry
Associate Director
Health Sciences Division
International Development Research Centre
Ottawa, Canada

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By Michael G. McGarry[1]

INTRODUCTION

In recognition of the many unhappy experiences incurred while trying to foster development through urban and industrial projects in the developing countries, international assistance organizations are now being advised to 'think small', while placing rural development as their first priority. Technology has become recognized as an important component of any development package. It is difficult, if not impossible, to effect change in a foreign economy and culture without building the development package around some kind of technology, whether it be a hydro-electric dam, water supply system, new variety of crop, or fish culture pond. Much of the technology offered over the past three decades has failed to engender the kind of changes that are now considered desirable. Honest efforts are being made now by many to rectify these mistakes through a new medium or message called 'appropriate technology'. For the most part, the intent behind appropriate technology projects cannot be criticized. However, it is the simplistic nature in which they are being formulated and implemented that is most disturbing. Appropriate technology has come of age; it is now a movement, if not, to some, a religion. Unfortunately, it has found its roots

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[1]Associate Director, Health Sciences Division, International Development Research Centre, Box 8500, Ottawa, Canada K1G 3H9.

in the industrialized states of the West, and not in the Third and Fourth Worlds, for which is largely intended.

The same international development agencies that have made serious mistakes in the past are taking up the appropriate technology banner. It is becoming our new message to them. Again, overly simplistic solutions are being carried across to solve the same complex problems of development. The 'technological fix', as the panacea of development, is again being promoted by the West. This time, however, it focusses at a lower technological level, on an even more vulnerable and more complex sector of the developing country.

The need to reduce the dependency of the poorer nations on the more wealthy is well recognized, yet new appropriate technology organizations are being formed in the industrialized states to foster the rediscovery, innovation, and development of appropriate technologies at home for later dissemination to the poorer societies. This can only increase dependency and continue to reduce self-confidence and self-reliance.

There are a host of definitions for appropriate technology in the rapidly expanding literature on the subject and I don't intend to add to it here. However, the word 'appropriate' doesn't provide adequate description, other than indicating that the technology should be 'good' or 'relevant' in any context in which it is placed. It would, therefore, be useful to list some of the general characteristics of appropriate technology - at least within the context in which this paper is written. Appropriate technology should:

- be aimed at the poorest and most underprivileged sectors

of society;

- raise the self-confidence of its maker or user;
- be not only economically viable but also socially, culturally, and politically acceptable;
- consist not only of the physical technology - the hardware, but also the software intangibles such as organization, education, extension services, supportive institutions, and surrounding economic considerations;
- be accessible to the poorer sector of the society intending to use it and be of proven technical efficacy under local conditions;
- foster a more equal distribution of wealth and power in the community and/or society it serves; and
- preferably be innovated, developed, disseminated, and maintained using manpower, institutional and material resources within the developing country itself.

Two of the above attributes need emphasizing. The first is that appropriate technologies should result in a more equal distribution of wealth. There is a natural inclination to support the more educated, organized and wealthy, inasmuch as they have the greatest resource base, have more capital to invest, are more technically competent and offer the easiest route to project implementation with the least chance of failure. Appropriate technology should support the less wealthy and less powerful. This can be accomplished through careful design of the technology, extension and educational services, and collectivization of the users. This approach contrasts sharply with the industrialization policies propagated in the past, and will likely prove to be a major stumbling block to the Appropriate Technology Movement.

The elite of society, who have prospered through industrial development, are unlikely to support the introduction of technologies and systems which may disturb their power base. On the other hand, appropriate technologies are likely to gain more official support by governments which are well motivated toward improving conditions in their rural areas and committed to more egalitarian distribution of wealth.

Secondly, there is an undesirable tendency for development agencies in the industrialized nations, which inherently lack first-hand experience in rural villages,to attempt innovation of technological solutions to what they feel are the highest-priority problems of the community. Villages are assumed to be of uniform character throughout the developing world. Worse still, the innovator of the West all too often develops a technology in answer to an imagined problem first, and then proceeds to search overseas for situations in which to apply it. This approach, which is based on a critical lack of information, is highly subject to failure at high cost to the innovator and his funding agency, and more importantly, to the developing country itself and to the community he involves in the project. The entire process of identification of needs, innovation or adaptation, implementation, and institutional support development should take place in the country in which the technology is applied and by nationals of that country.

EXPERIENCES WITH TECHNICAL ASSISTANCE

Undoubtedly, there are many technical assistance programs which have achieved success in introducing change for development.

There are, however, a disturbingly large number which have not. There are several inherent features in the donor/recipient relationship, and of the donor agency itself, which presuppose failure. The donor countries tend to be ethnocentric and paternalistic in their aid programs: "What we have is best; we know best who needs it; and how it is best delivered".

Aid is seldom altruistic. Often it is intertwined in political and economic strings, which result in net negative benefits to the recipient, who may well have been coerced into accepting the aid package in the first place. Earlier development strategies aimed primarily at maximizing output, while emphasizing the heavier industries. Such strategies are recognized today as not only ineffective in achieving their goals of economic growth but also as a contributing factor to social setbacks and disruption. They are largely responsible for the uncontrollable growth of slums in the primate cities, and a widening gap between the modern and traditional sectors of society.

Assistance to the manufacturing industry, either through aid or on a commercial basis, is often in the form of outdated, inappropriate technology transferred to the developing country. This is aimed at import substitution of consumer goods by local manufacturers for the higher income markets. It has not placed the developing country in a competitive position on the world market. A recent USAID survey of U.S. multinational corporations with branch plants in the Third and Fourth Worlds illustrated that they are loath to invest funds and engineering time in changing product design suitable to developing country conditions. "The development or adaptation of simplified, but modern

products for low-income markets by the large multinationals has not occurred often in the past and does not seem likely to expand in the future." (2)

Mendis (9) speaks against the large-scale commercial system which has been propagated by the West and adopted by many developing countries, including his own, Sri Lanka. Despite the existence of productive capability in traditional technologies, which could have been improved and focussed on appropriate technologies, a process of imitative development has been followed. This has seen the import of large-scale, production-commercial systems. There are several deficiencies associated with such direct transfer of technology to an essentially non-industrial state. Apart from the environmental consequences of the centralized factory and the rural-urban migration, labour-saving devices have reduced the worker from an apprentice and craftsman to a minder of machines. Further, import of modern manufacturing capability in Sri Lanka has been shown in many cases to compete with existing small-scaled, rural-based industries. (2) For example, the village pottery industry had been supported by the Department of Small Industries and could have formed the basis of a rural ceramics industry. Instead, a foreign ceramics manufacturer was invited to establish a large factory in Colombo. It successfully suppressed the traditional pottery industry by penetrating the rural market and creating new demands for its products, thereby forcing the market by creating such demands instead of responding to its real, but limited needs. Mendis gives several other examples, amongst which is the introduction of centralized electricity supply through a national grid to

replace decentralized, dispersed, hydro-power sources used on rubber and tea estates since colonial times. Now that energy costs are rising, desperate efforts are being made to locate alternative, decentralized sources.

One of the most denigrating consequences of foreign assistance arises from reliance on foreign advisers or experts. Short-term or long-term, these consultants are welcomed by aid agencies as a means of giving aid funds but keeping them 'in-house'. They are also useful as absentee scapegoats when mistakes later surface and someone must be blamed. Undoubtedly, the practice of using a foreigner as a change agent has its advantages; but it ultimately results in overshadowing local professionals. In the eyes of the bureaucrat, the foreigner is always right; overseas technologies and methods are always superior to the indigenous. In face of this, the local professionals are relegated to a second-class status and seldom given the opportunity to acquire the necessary self-confidence and esteem.

The process is termed dependent development; unfortunately, the tendency to rely on overseas assistance persists into subsequent projects and activities. Other, well-known, negative side-effects of this kind of aid arise from assistance through overseas education programs in the form of the 'brain drain' from the developing to the developed countries. The cream of the student crop is first selected for training in the donor country. This is paid for by funds which, again, are spent 'within-house'. After graduation, the graduate returns to his country, often under a bonding arrangement; but his professional advice is widely ignored, if indeed he is asked for it at all. Consequently,

he frequently welcomes the opportunity to return to the country of his education - as part of the brain drain. Funds spent on his education are spent in developing educational facilities in the industrialized state, not at home; similarly, his education and research work also pertain to the developed economy and are frequently inappropriate for application at home. Inappropriate technologies continue to be perpetrated through the overseas educational system; lack of adequate educational facilities in the developing country persists and so does dependency on external aid sources.

APPROPRIATE TECHNOLOGY GROUPS

There is nothing new or mystical about appropriate technology in the developing country. Presently, however, international attention is becoming focussed on it as a new medium through which aid can be given. A bewildering array of groups have been formed to advance the cause of appropriate technology, which has been capitalized and elevated to the state of an Appropriate Technology Movement.

Appropriate technology groups may be broadly classified into three categories. In the first category are the rural peasant and indigenous industries of the developing countries themselves which have innovated and applied relevant technologies through the centuries. There are probably millions of appropriate technologies employed in rural areas of the world, covering a much broader range of activities than the newly formed intermediate technology groups would suggest. Examples given by Jéquier (5) include the windmills of the coastal flats of Thailand, used to raise seawater to

evaporate in shallow ponds for the production of salt. Another is the Philippino entrepreneur who built a starch separation plant from second-hand washing machines and gave such competition on the market that he forced closure of a newly built, 1½ million dollar 'modern' plant.

The second group of appropriate technologists are more formally instituted and are to be found within government, private or semi-public institutions, or universities. They are primarily concerned with the development of hardware and may consist of an individual research effort, such as Dr. H. Montemayor's village-scale infiltration gallery research at the Panamanian Polytechnical, or a multidisciplinary team of researchers such as that within the Ministry of Local Government and Lands, of Botswana, investigating alternatives to urban sewerage.

The third category is represented by the multinational groups, such as the Intermediate Technology Group (ITG), of London; or the Volunteers in Technical Assistance (VITA), of the United States. It appears that most of the driving or motivational force and certainly the funding for the Appropriate Technology (AT) movement comes from the industrialized states. Indeed, most of the activity is taking place in the industrialized states. This has given rise to accusations that appropriate technology is yet another form of neo-colonialism. Rybczynski points out that the "colonial connection could bear further inspection, as the Appropriate Technology movement is firmly grounded not, as one might expect, in an underdeveloped country, but in Great Britain. Recently it has spread to Holland, France and the United States".(10)

Funds are readily available for application of appropriate technology to international development. It appears that the large sums becoming available will surpass the capacity of the developing countries to absorb them effectively. By its very nature, appropriate technology is small and widely dispersed over the rural areas. The huge sums spent in the past on capital-intensive projects oriented toward the growth of the industrial/urban sector will be difficult to spend effectively on appropriate technologies. The engineering consultant and equipment firms are not attracted to labour-intensive, simple technologies, however appropriate. Lower-technology projects cannot be used to manipulate development from the outside, as can hydro-electric dams. Consequently, we can expect to see a proliferation of AT groups in the West and an increased use of expatriates as managers of externally motivated AT projects in the developing countries.

The USAID is supporting development of the largest group of all: Appropriate Technology International (ATI). Although commendable in many of its objectives, ATI intends to involve U.S. business in appropriate technology programs in developing countries. This will be accomplished by facilitating direct investment or through organized transfer of relevant business management experience and technology. Serious suggestions are being made that monetary incentives should be offered to encourage U.S. business to consider alternative technology, such as the provision of grants to U.S. equipment manufacturers to encourage the development of appropriate technologies for less-developed countries. (2) Such activities are hardly likely to result in the development of innovative capabilities and self-confidence in the developing countries themselves.

The ATI objectives of improving communication among practitioners of AT, evaluating experiences, and assisting in-field projects are commendable. It is not the objectives themselves which are in question; it is how they may be achieved, who will implement them, and where. Past experience indicates that American institutions and personnel will be heavily involved, both at home and abroad. Funds are likely to be spent largely in-house. The ATI Board of Directors, which is responsible for policy decisions, is composed entirely of Americans; there is no developing country representation on the Board. There is much heavier representation of business on the Board of Directors of ATI than in most AID activities. The initial fund for this activity is $20 million.

The greatest concern of all is that along with increased involvement of the bilateral agencies in appropriate technologies comes excessive and short-term funding tied to the requirement of using donor country personnel. Even if these funds are untied, their very magnitude will necessitate their being spent on expatriate personnel in order to meet budget-spending guidelines. Expatriate personnel used to direct field projects seldom have adequate knowledge of or experience in the rural areas in which they are contracted to work. As a consequence, they and their projects are likely to concentrate on hardware, at the expense of social, cultural, and organizational aspects. This is a practice proven to be highly susceptible to failure. Examples are already starting to appear. A major alternative energy project in the Philippines, which is supported by UNEP, includes studies on biogas, fish culture, low-cost building materials, solar energy, and bamboo production. All but the bamboo research are dependent

upon foreign consultants; all projects are heavily oriented towards demonstration of only the hardware.

With every good intention, UNICEF created the Village Technology Unit near Nairobi to act as a demonstration centre of appropriate technologies for farmers. A myriad of gadgets are on display; only a few are actually relevant. Unfortunately, management of the Unit is UNICEF and not Kenyan dominated. Less than 5% of visitors to the Unit have been Kenyan farmers; the vast majority of visitors have been international travellers representing the UN, other development agencies, and local bureaucrats from Nairobi.

Amongst all the rhetoric about appropriate technology also being concerned with the institutional and social aspects, and despite these aspects being the greatest constraint to dissemination of appropriate technologies, very little effective action is being taken by the West's AT groups and international agencies in these directions. Understandably, it is difficult, if not impossible, to account for such software under existing constraints of personnel, time, and distance, which beset the industrialized-states based groups. It could well be that as far as AT projects are concerned, the international AT groups would best:

(1) confine their funding to a level which can be absorbed and effectively managed by the developing country groups and practitioners;

(2) limit the use of contracted expatriate personnel within the developing countries; and

(3) focus more on global aspects of appropriate technology, such as information exchange programs and inter-AT project activities such as the ITDG is now doing.

THE PROBLEMS OF APPROPRIATE TECHNOLOGY

The difficulties of international involvement in appropriate technology efforts within developing countries have been described. These underline the need for the entire process of AT development to originate and be implemented within the developing country by nationals and institutions of that country. The process of developing an appropriate technology begins with a definition of needs. All too often, these needs are defined in Washington, London, or Ottawa, and are based on what are perceived to be village needs, in relative ignorance of the complexities of rural society and its economic determinants. These needs should be defined within the developing country and with full participation of the community concerned.

Not only needs identification but also the process of innovation should take place in the developing country. However, there is a basic lack of self-confidence resulting from years of dependance on the more wealthy powers for transferred technology. Potential innovative capability does exist and research institutions are growing in number and quality. There is, however, a stigma associated with the lower technologies. Researchers, many of them trained overseas, are often loath to address the real problems facing their rural peoples. They continue to respond to the demands of publishing internationally and thereby select research topics of greater interest to the industrialized country academic than local peasantry and small industry. Promotion criteria within research institutions relate to politics and seniority, not excellence. There is a need to free the researcher from these restraints and frustrations and for him to focus on the

practical problems facing his society. Another potential resource which must not be ignored is the artisan, the peasant himself, the 'bricoleurs', whom although difficult to incorporate into the formal system, were primarily responsible for the technology of the Industrial Revolution, long before the advent of the R and D Department.

AT innovation requires an appropriate setting in which to work. It needs institutional support and facilities as well as competence through adequate manpower. Risks associated with research ventures have to be recognized as being legitimate and in this way, they need to be reliably and well funded. Communications with other research groups have to be strong and information systems well developed. Most of all, the researcher must find incentives to innovate which are not only monetary. He must perceive a real chance of his product being developed and marketed.

One of the primary functions of the multinational AT groups has been to disseminate descriptions and designs of technologies. Unfortunately, seldom are the technologies evaluated prior to dissemination. What evaluation is done is often limited to its reported success in a specific situation or geographic region. Sometimes the hardware is tested empirically under repeated cycles of operation, but only under laboratory conditions; the evaluation is thus limited to a purely technical evaluation. There is a great danger that such evaluations will be used to justify the application of the technology on a broad scale in other regions. The danger is not so much that the equipment will break down, but that when it does, the communities become sceptical of further technical interventions and resistant to suggestions of change

from the outside. Failure of a technology is often a result of its incorrect introduction to a community (e.g., without appropriate regard to existing patterns of authority and decision-making); aesthetic unacceptability; incompatibility with the class, hierarchical structure, or the social mores of the society; or of its giving economic advantage to the more wealthy. Although some generalizations of village conditions are legitimate, evaluation of a given technology should be made on a case-by-case basis by the communities involved.

No matter how effective the technology is in the hardware sense, its success depends on an effective delivery and maintenance system which fosters its acceptance and continued use by the community. The rate of acceptance of the technology is greatly enhanced by the ability of the potential user to participate in its assessment himself.

> "Yet there are strong indications that a substantial proportion of the development projects based on appropriate technology are for the time being of a non-participatory nature: the beneficiaries of these innovations are not directly involved in the definition of their major needs, and they do not take any direct part in the development, testing and improvement of the technology which is offered to them." (1)

Some form of extension service, village capability or at least availability of spare parts, must be instituted to ensure proper use and maintenance of the technology. Extension services have not had an exemplary history inasmuch as they have tended (with some notable exceptions) to act as providers of information

but not take adequate account of the need for local participation. The problem is not of the technology itself but rather the way in which it is introduced and the quality of continuing services provided.

Three examples of civil engineering technology delivery are given below. The first is the much-talked-about biogas plant which has had a checkered past, being too expensive for the individual farmer to afford but technically effective and relatively simple to operate. The second is the village water supply system, which although meeting technical design standards, almost invariably suffers from lack of institutional support for its continued maintenance and repair. Thirdly, urban systems of wastewater collection and disposal are considered and sewerage condemned, as being far beyond the means of the urban poor and therefore inappropriate.

THE BIOGAS PLANT

The biogas plant has recently gained wide publicity as a resource-recycling technology appropriate for developing countries. It operates on the same anaerobic digestion principle as the anaerobic digester used in conventional primary sewage sludge treatment. The tank, made of concrete placed in the ground or flexible butyl rubber, is daily fed water and organic farm and household wastes, sometimes including human excreta. The mixture ferments without air to produce a gas composed of carbon dioxide and methane which is used primarily for cooking and lighting in the household. The digested waste material comes from the tank in the form of a slurry which is essentially

odourless, innocuous and can be reused as a fertilizer either directly or after drying or composting with other farm waste materials. The biogas bubbles out of the tank's digesting material and is caught in a gas holder shaped as an upside-down mug; it rests on the tank's liquid surface. The gas holder rises and falls with production and use of the gas, which is drawn off through a flexible tube to the nearby household.

Technically at least, the concept has considerable appeal and has gained wide popularity in the West with the rise of the AT Movement and the publication of several articles by Fry (3) and Singh (12). These praised the biogas plant's technical attributes without concern over its costs or how it might relate to the socio-economic and organizational patterns of the rural areas of the developing country. Many demonstration units have been built (few of them actually operating on a continual basis for want of input material) in the West. More serious fundamental research is being carried out in universities of the U.K., the U.S., and Israel, but the technologies being considered are too high to be applicable to the rural peasant. Biogas plant technology is indigenous to Asia. A great deal is published about the original work being carried out in India, where 36,000 have been built; few, however, realize that parallel developments have taken place in Korea and China, where 27,000 and 80,000 plants have been installed, respectively.

The international agencies and appropriate technology groups found biogas to be highly attractive, particularly the UN Economic and Social Council for Asia and the Pacific (ESCAP), which held meetings in India and the Philippines on the subject. These were

attended by biogas technology proponents and focussed, once again, on the hardware and how it should be promoted across Asia without concern over its many failures in the past. UNEP has supported demonstration projects in biogas while UNIDO, UNDP, UNICEF, WHO, the World Bank, and the International Development Research Centre are taking a more cautious stance; the latter is particularly interested in technical, social and economic evaluation of biogas systems and is supporting activities in Asia towards this end.

Success of the biogas plant in Asia is varied, being affected by numerous interrelated factors. Dominant motivation for adopting biogas plants varies between and even within countries. The gas as used for cooking does, however, appear to be the primary benefit, with the manurial value of the slurry often being given only marginal emphasis. The more hidden benefits related to public health and reforestation are recognized only by the governments which provide grants or soft loans (but decreasingly so) to individuals interested in installing biogas units. Korea is now withdrawing its credit facilities to farmers wishing to install biogas units. Such credit has been regarded as essential to the expansion of biogas programs in both India and Korea. The major constraints to biogas in rural areas pertain to the software. In particular, extension services vitally needed for maintenance and repair are often lacking; similarly, credit facilities are commonly cumbersome. One fact which is common to most situations where the plant is individually owned is that the biogas plant can only be afforded by the wealthier farmer, as the landless labourer or tenant has neither the required capital to construct nor the animals to feed the system. Water and land also pose problems where they are not

readily available; in particular, the land required for slurry drying or composting has a high opportunity cost in urban or peri-urban situations.

Evaluating the biogas plant is complex and site specific. A dearth of basic information exists with respect to the capital costs of the biogas unit, cost of land, the dung produced by animals, seasonal fluctuations on demands, availabilities and values of resource, inputs and products, product yields, etc. There is a dire need for site-specific, socio-economic evaluations, the innovation of less expensive designs, and the identification of those social and economic conditions under which biogas plants have the greatest chance of success before being propagated across the developing world.

VILLAGE WATER SUPPLIES

In the eyes of the so-called 'developed society', clean water is seen as a prerequisite for comfortable, healthy living. This is feasible because acquiring water takes up only a very small percentage of the American or European income, and the thought of a cholera or typhoid epidemic running through New York or London via the water supply is truly horrific. Consequently, there is a serious danger that we, the 'international water engineers', will transfer these concepts and practices to developing regions where such diseases as cholera and typhoid are commonplace, indeed endemic; where their normal transmission routes have little to do with the water supply; and where the people simply cannot afford to pay for water supplies. These regions tend to accept external help and with it externally determined development priorities

which may have little or nothing to do with their real needs.

On the other hand, there are areas which are in dire need of improved water supplies, where during the dry season women must spend a good portion of the day walking five or even ten kilometers to scrape water from a muddy hole. These water-scarce areas justifiably demand first attention, but this justification is based on labour and time savings and not on health. There is too great a temptation for the politician, the UN delegate, the aid agency employee, the international consultant and the water engineer to simplify and generalize the solution using water as a panacea, and climb on the next international bandwagon with such catchy phrases as "Clean Water for All"!.

It's just not that simple. If limited finance and even scarcer human resources are to be effectively spent on improving health, we must recognize that water delivery is only one element in a complex matrix of activities which must go on if it is to have any significant effect on health. The question is not how many water supplies can be installed over a given period of time, but why and how they are implemented; to what effect; and most important of all, at what opportunity costs.

Rural water supplies have recently become the focus of international attention. The idea of clean water, plentifully available in an otherwise destitute rural village, is highly attractive to the politician. It also appeals to the international bank, and to UN agencies and aid organizations, who are now searching for ways in which to direct their efforts towards rural development. Despite their good intentions, international aid organizations are limited to participating through financial and technical assistance

and thus have become highly technology oriented.

The result of all this will likely be the release of large sums of aid funds to provide inducement for a more rapid expansion of rural water delivery programs; but here money implies technology, and technical solutions will be sought and pressed into service to meet the construction targets set by the funds being made available. Unfortunately, there is a severe shortage of experienced manpower capable of implementing effective rural water delivery programs in both the donor agencies and recipient countries alike. This, coupled with the inherent difficulty of successfully introducing any kind of technology to the rural community, will likely result in gross errors and financial resources being wasted at high opportunity cost.

Examples of such failures are not difficult to find - they exist in most African countries, where lack of maintenance and repair capabilities in rural areas is exasperated by the import of inappropriate well-drilling equipment and several varieties of handpumps more suited to the back garden of the Western farmer than the centre of a drought-prone, populous village. Henry (4) gives an example of one Asian country in which approximately 50,000 village wells have been drilled in hard rock at a cost of $40 million in water-scarce regions; an estimated 80 percent of these wells are no longer producing water. The problem is not only technical; the pumps are installed with insufficient involvement with the village - the site for locating the pump is selected by the engineer, not the village leader. The villager views the pump as belonging to the government department which installed it and therefore he accepts no responsibility to look after it.

In Bangladesh, clean water supplies to villages are being installed through a major UNICEF program providing thousands of handpumps to villages to combat endemic cholera. The mere supply of handpumps has done little to alter water-use practices and hygiene in the home. Consequently, it was not a surprise when after two separate field investigations, the Cholera Research Laboratory in Dacca found no significant reduction in cholera in families using the handpumps for drinking water. (6)

There are some success stories: in Malawi, for example, village participation was the key to success in bringing piped water to over 150,000 villagers falling in the water-scarce category at a cost of less than $3/capita. The Department of Community Development and Social Welfare began on a small scale by physically demonstrating that one could transport water through pipes from a perennial mountain stream several kilometers away. Convinced, the villagers participated by digging all the trenches, laying the pipes and constructing the concrete aprons and soak-away pits around the village taps. This initial demonstration mushroomed; soon the demand for piped water outstripped the capability to deliver it. The barefoot engineer concept has been introduced in the form of rural water technicians for this ever-expanding activity. Three-week technical courses are conducted under tents for carefully selected, technically oriented men with limited education; this training also includes a major community development component. Initially the piped water projects were small in size and made use of demonstrations and examples so that the villagers knew exactly what they were getting into. Now, large public meetings are held to ensure that any

commitments being made are fully understood and acknowledged by all. More importantly, this approach involves the people not only as labourers, but in decision-making roles so that they are, to a large extent, responsible for the success of the system and willing to be responsible for its continued maintenance and repair. (8)

The community development approach taken in Malawi took a decade of patience, understanding, and hard work to achieve. Unfortunately, the urgency with which international funds will have to be spent, the commercial drive of equipment manufacturers and the inexperience of agencies in dealing with rural peoples are likely to result in no heed being taken to this example of success.

URBAN SEWERAGE

It never ceases to amaze me how in designing interventions to reduce the incidence of gastroenteric disease, we go to such lengths to ensure that the water supply is 'pure', when water is only one of a multitude of inputs to the gastroenteric system. The problem is at the anus, at the source of contamination; would it not, therefore, be better to cut transmission at the beginning of the feedback loop before it spreads through the household environment?

When the Western environmental engineer does evolve solutions for urban excreta disposal, he almost invariably bases his design on waterborne sewerage. This method of excreta management involves dilution of the waste in its most concentrated form with treated potable water solely for the purpose of its transportation.

The resulting sewage, made up of 99.9 percent water, is flushed through a system of subterranean pipes and pumping stations connecting all serviced buildings to one discharge point. Realizing that direct discharge of large volumes of waste is detrimental to the receiving resource, the objective becomes one of repurifying the water and reconcentrating and treating the waste. In short, this process of diluting waste for purposes of transportation and then concentrating it again at the treatment plant does not make sense, either economically or in terms of resource conservation.

Transporting faecal matter by water gained widespread popularity during the Industrial Revolution; the concept has remained unaltered to this day. Coming in the Victorian era when "cleanliness was next to Godliness", the concept of flushing away one's wastes was an attractive one indeed. Sewers were advocated as the solution to the human waste problem in the cities. The wastes had to go somewhere; most often they were discharged and effectively treated by the river. Inevitably, with the growth of the city and increased volume and complexity of wastewater, the self-purification capacity of the river was surpassed. Treatment before discharge became an expensive necessity.

Meanwhile, in China, the technological era had not arrived; human wastes were looked upon as a natural resource of nutrients for plants. Instead of the growing cities being regarded as an undesirable source of river pollutants, they were viewed as a valuable source of fertilizers, where the farmer could purchase excreta from the housewife at relatively little cost. The two

approaches to essentially the same problem exemplify the philosophical disparities between the two societies. To Western thought, human excreta are useless, undesirable waste products to be disposed of as quickly and as inoffensively as possible. To the Chinese, nightsoil is a desirable resource. With economic and population growth, the exhaustability of our water resources is putting an end to indiscriminate discharge of wastes to the environment, yet alternative approaches which are socially acceptable in Western eyes are expensive. In contrast, the Chinese continue to utilize excreta for agricultural development and by doing so provide a positive monetary incentive for pollution control.

Sewers are expensive. On a per-household basis, they are far more expensive than coloured television sets. In the face of this, however, the urban planners insist that sewers are both desirable and necessary; but why? Firstly, there appear to be no alternatives: no technologies to fill the gap between the unsatisfactory pit privy and sewerage. Such is not the case. Systems are in use in developing countries which are appropriate and which could be upgraded and properly designed to provide adequate service at low cost. (11, 13) Secondly, concepts, practices and attitudes imported mainly from the West have artificially raised the desires of the policy-makers to technologies which simply cannot be afforded by their people. Thirdly, the dependent developing country often requests assistance from bilateral aid or UN organizations in the form of feasibility and master plans for wastewater collection systems. In keeping with the principle of spending aid funds 'in-house', Western engineering consultants are contracted. The consulting firms are constrained by lack of

experience and expertise and limit their choice to piped sewerage. In several cases there has been outright refusal to consider alternative methods. This attitude is understandable: consulting engineering firms are professionally responsible for the designs they propose; their reputations, upon which their business is based, depend on the success of implemented schemes. As such, they can hardly be expected to endorse technologies with which they have had no experience. There is a case here for the purposeful development of local engineering capabilities in the Third World. They are familiar with conditions there and are not bound to design criteria and technologies of the industrialized states.

Under the guise that any planning exercises are worthwhile; that baseline data will be useful when sewers can be afforded; and that the plan was 'given' to the recipient country without cost, sewerage master plans continue to be developed. There are, however, many hidden costs to this exercise in negative aid. Firstly, the funds spent on developing master plans (normally approximately ½ - 1 million dollars) could be used elsewhere. Secondly, a large number of qualified personnel from the developing country spend valuable time on this useless planning exercise which they can ill afford. Thirdly, the plans which are developed, after being shelved for several years, fall out of date and are seldom used. The most adverse side effect of all is the perpetuation of the attitude that there are no other financially feasible methods of excreta collection and disposal, which results in indefinite postponement of rational attempts to solve the urban sanitation problem.

A cost-benefit analysis of sewerage was attempted (7) despite the inaccuracies of assessing the more intangible benefits. It served to demonstrate not the final, internal rate of return or benefit-to-cost ratio (which was less than one) but to illustrate economic characteristics of urban sewerage:

(a) the required construction periods are necessarily extended to very long periods due to budget constraints;

(b) the time at which benefits are likely to accrue from sewerage is in the distant future because the main sewer and lateral system need to be complete before significant numbers of house connections are made;

(c) heavy investments are required in sewer mains during the first stages of construction; these are not matched by early revenue returns or health benefits;

(d) in order for a municipality to invest in a sewerage scheme, a very high value must be placed on unquantifiable environmental and amenity benefits, as health benefits are minor relative to the capital outlay required for construction and maintenance of the system; and

(e) the health benefits are realized so late in the project that they tend to lack significance when discounted back to the time when the investment decision was made.

The developing countries are currently having considerable difficulty in providing urban wastewater management services. The central reason behind these difficulties is the inappropriate technology they are trying to apply. As transferred from the industrialized states, sewerage is very capital intensive and

labour conserving during its operation: quite the opposite to those cost characteristics which are required.

CONCLUSIONS

In conclusion, I would like to emphasize five points, as follows:

1. To be appropriate in the developing country context, technologies must not only be technically viable but also account for the social, economic, organizational and cultural milieu in which they are found.
2. Wherever possible, the entire process of appropriate technology innovation, development, dissemination and implementation should be carried out by developing country nationals in the country in which the technology is to be applied. The intended user should also participate.
3. As priorities, international appropriate technology groups should focus on information dissemination and inter-project activities.
4. International funding of basic and applied research and development of appropriate technology should recognize the limited capacity in developing countries to effectively absorb such funds; funding should be constrained to suit that limited capacity and to avoid the temptation of 'delivery technology' via expatriate 'experts'.
5. There is nothing new in appropriate technology; it has been used in the developing world for centuries. Its newly found popularity emphasizes its considerable value as a means of reorienting development assistance programs to effect more

equitable distribution of wealth in the developing countries. There is, however, a dangerous tendency to oversimplify its dissemination and application, a process which is extremely complex - particularly within the rural societies.

APPENDIX I - REFERENCES

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